THE GLOBAL SHAPE OF MARS: PRELIMINARY RESULTS FROM A REANALYSIS OF THE VIKING MARS CONTROL POINT NETWORK. W. Zeitler, J. Oberst, *DLR Institute of Planetary Exploration, 12489 Berlin, Germany, Wolfgang.Zeitler@dlr.de*, T. Ohlhof, *Chair for Photogrammetry and Remote Sensing, Technical University Munich, 80290 Munich, Germany, timm@photo.verm.tu-muenchen.de*.

INTRODUCTION

The global shape of Mars is poorly known. Previous studies included radar profiling from Earth, spacecraft occultation measurements, and control point network determinations. Radar profiles are available only locally and are not appropriate in the study of global shape. Spacecraft occultations [1] generally result in a sparse global distribution of topographic data points, but due to the large gaps have poor spatial resolutions. Previous control point network analysis [2],[3],[4] suffered from a poor knowlege of gravity field parameters and Viking orbit data. In addition due to lack of computing power, the block adjustment for large numbers of control points (which requires solving large sets of linear equations simultaneously) was a difficult or impossible computational task. Hence, some of the previous control point network analyses were limited in their complexity and involved 2D surface coordinates only.

During the past years, computer power and the quality of available Viking orbit data has greatly improved. Also, access to Viking image and ancillary data is greatly facilitated by today's availability of these data on CD ROMs rather than the previous 1600 mm tapes. Spacecraft trajectory and camera pointing data are available in standard data (SPICE) formats. With the imminent arrivals of Mars Global Surveyor and Mars Pathfinder, we carried out a re-analysis of the USGS Viking control point network to update our current models of global shape.

INPUT DATA

We adopted the original set of image coordinates used in the previous control point network analysis [4] for initial test runs.

After inspection, we selected 85% of about 19 000 image coordinates that were measured in 1 097 images, with the remainder being discarded because of inconsistencies found in the dataset. These observations belong to a total of 3 226 tie points, each of which was measured in three or more (on average five) images.

Trajectory data were derived from a new Viking orbit determination project [5],[6]. The accuracy of the new orbit information was increased ($\sigma \approx 500$ m) due to availability of an improved Mars gravity model [6] and a refined general motion model (i.e. ephemeris of the planets and the Sun). Simultaneous processing of the tracking data of all Viking 1 and 2 orbits was achieved. Former tracking data had been processed piecewise during the mission as the data was received. A comparison gives 20 km difference on average between the old and the new trajectory data. The original Viking attitude data which comprise the three orientation angles for each image were introduced into the adjustment without modifications. The position and attitude data were transformed into a Mars-centered (Center of Mass), Mars-fixed non-inertial coordinate system, where the rotational parameters of Mars were treated as constants.

BUNDLE BLOCK ADJUSTMENT

In a bundle block adjustment 3D ground coordinates of the tie points are determined and the exterior orientation (position and attitude) of all images reconstructed [7]. The mathematical model of the bundle adjustment is based on the collinearity equations which relate the observed image coordinates x_{ij}, y_{ij} to the unknown ground coordinates X_i, Y_i, Z_i of the point P_i and the unknown parameters of exterior orientation $X_{0j}, Y_{0j}, Z_{0j}, \phi_j, \omega_j, \kappa_j$ of the image I_j. Additional observation equations are introduced for bias and drift of the position and attitude data. No ground control information was introduced in the block adjustment. For the bundle block adjustment the software package *CLIC* [8] was used.

PRELIMINARY RESULTS

To our knowledge, we are the first to compile a large global Mars control point network involving 3-dimensional coordinates within one single block adjustment. After 12 iterations a $\hat{\sigma}_0$ of 12.5 μm (= 1 pixel) was achieved. The rms values $\mu_{\hat{X}}$, $\mu_{\hat{Y}}$, $\mu_{\hat{Z}}$ of the theoretical standard deviations of the adjusted ground point coordinates amounts to about 2–3 km. These were about 4–5 km in the previous USGS network. The coordinates in the USGS network differ to ours by 5–20 km. Using these ground points, a sphere and ellipsoids with two and three axes were fitted to describe the reference body of Mars:

- sphere:
  r= 3390915 m +/- 116 m
- 2-axial ellipsoid:
  a=b= 3394505 m
  c= 3377670 m
- 3-axial ellipsoid:
  a= 3400534 m
  b= 3393931 m
  c= 3377581 m
  λ_a= 112.5°

These values are still very preliminary and their errors will be discussed. Heights of individual points range from -19.4 km to 22.4 km with respect to the 2-axial ellipsoid. We also interpolated between the control points to obtain a contiguous global map, in which we clearly identified major topographic features such as the Hellas and Argyre impact basins, and the Tharsis volcanoes. This demonstrates that the spatial resolution of our model greatly exceeds that of recently derived global shape models from occultation data [1].

OUTLOOK

In this study we have derived the currently best model for the global shape of Mars. This model will be greatly improved with the availability of laser altimeter data collected by the MGS spacecraft [9]. Our precise coordinates of large numbers of landmarks can be used for spacecraft navigation of this upcoming mission.

To further improve our current version of the control point network future studies will include: (1) Remeasurement of image coordinates in the original images in stereo using a digital (softcopy) photogrammetric workstation. (2) Incorporation of additional image coordinates from the RAND network [2]. (3) Incorporation of image coordinates of new tie points, measured automatically and/or manually. (4) Verification of the model for the determination of the interior orientation parameters. (5) Incorporation of one or more ground control points (e.g. VL1, VL2, Airy-0). (6) Incorporation of orbital constraints into the bundle adjustment algorithm [10]. (7) Estimation of the Mars rotation parameters [10].

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